W91321-04-C-0023

LOGANEnergy Corp.

NASA Stennis Space Center PEM Demonstration Project
Final Project Report

Proton Exchange Membrane (PEM) Fuel Cell Demonstration
Of Domestically Produced PEM Fuel Cells in Military Facilities

US Army Corps of Engineers
Engineer Research and Development Center
Construction Engineering Research Laboratory
Broad Agency Announcement CERL-BAA-FY02

Mars Exhibit, Visitor's Center, NASA Stennis Space Center,
Stennis, Mississippi

September 11, 2006

Executive Summary

In February 2003, Sam Logan of LOGANEnergy contacted Mr. Bob Heitzman, Director of Facilities Management, Stennis Space Center, about the possibility of hosting a CERL FY'03 PEM demonstration unit at the visitor's center. Since Mr. Heitzman had been involved with the earlier Stennis PC25 Demonstration Program, he responded favorably to the opportunity.

In June of 2003, LOGAN submitted NASA Stennis Visitor's Center as a candidate site for the FY'03 PEM Program. However, in July of 2003, CERL indicated that it would prefer to include Stennis with funds left over from the FY'02 PEM Program, and in August 2003, LOGAN received a contract to proceed with the Stennis PEM demonstration project.

The unit was initially planed for installation adjacent to the visitor's center, but at a meeting in March 2004, Stennis advised LOGAN the unit would be placed next to the Mars Habitat display on the north side of the visitor's center.

Installation of the unit commenced in June 2004. On September 1, 2004, the unit was commissioned and started in a grid parallel/grid independent CHP application. The unit was thermally integrated with a pre-commercial DryKor liquid desiccant air conditioning unit to provide cool, dry, fresh air to the interior of the Mars Habitat.

On August 29, 2005, Hurricane Katrina struck the Gulf Coast with devastating winds and major flooding. The western wall of the hurricane eye passed over Stennis causing significant damage to the base. At that time the unit had been operational for 13 months and had achieved 84% availability. LOGAN projected that the unit would need to run until the end of the year to reach 90% availability. However, in the aftermath, Stennis advised LOGAN that the project would have to come to a close since the Mars Habitat display had been destroyed and all of the facility's energies were directed to disaster recovery and rebuilding. Since the base was closed to visitors for three months following the hurricane passage, LOGAN was unable to restore the site until January 2006.

Mississippi Power was the utility service provider during the project. Hancock LPGas provided fuel for the unit. The additional cost for Stennis to host this demonstration project was estimated to be $1,449.

The POC for this project is

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Proposal – Proton Exchange Membrane (PEM) Fuel Cell Demonstration of Domestically Produced Residential PEM Fuel Cells in Military Facilities

1.0 Descriptive Title

LOGANEnergy Corp. Small Scale PEM Demonstration Project at the Mars Exhibit, Visitor's Center, NASA Stennis Space Center, Stennis, Mississippi

2.0 Name, Address and Related Company Information

LOGANEnergy Corporation

1080 Holcomb Bridge Road
BLDG 100- 175
Roswell, GA 30076
(770) 650- 6388

DUNS 01-562-6211
CAGE Code 09QC3
TIN 58-2292769

LOGANEnergy Corporation is a private Fuel Cell Energy Services company founded in 1994. LOGAN specializes in planning, developing, and maintaining fuel cell projects. In addition, the company works closely with manufacturers to implement their product commercialization strategies. Over the past decade, LOGAN has analyzed hundreds of fuel cell applications. The company has acquired technical skills and expertise by designing, installing and operating over 30 commercial and small-scale fuel cell projects totaling over 7 megawatts of power. These services have been provided to the Department of Defense, fuel cell manufacturers, utilities, and other commercial customers. Presently, LOGAN supports 30 Phosphoric Acid Fuel Cell (PAFC) and PEM fuel cell projects at 21 locations in 12 states, and has agreements to install 22 new projects in the US and the UK over the next 18 months.

3.0 Production Capability of the Manufacturer

Plug Power manufactures a line of PEM fuel cell products at its production facility in Latham, NY. The facility produces three lines of PEM products including the 5kW GenSys5C natural gas unit, the GenSys5P Liquid Propane Gas (LPG) unit, and the GenCore 5kW standby power system. The current facility has the capability of manufacturing 10,000 units annually. Plug Power will support this project by providing remote monitoring, telephonic field support, overnight parts supply, and customer support. These services are intended to enhance the reliability and performance of the unit and achieve the highest possible customer satisfaction. Vinny Cassala is the Plug Power point of contact for this project. His phone number is 518.782.7700 ex1228, and his email address is vincent_cassala@plugpower.com.

4.0 Principal Investigator(s)

Name	Samuel Logan, Jr.	Keith Spitznagel
Title	President	Vice President Market Engagement
Company	Logan Energy Corp.	Logan Energy Corp.
Phone	770.650.6388 x 101	860.210.8050
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Email	samlogan@loganenergy.com	kspitznagel@loganenergy.com

5.0 Authorized Negotiator(s)

Name	Samuel Logan, Jr.	Keith Spitznagel
Title	President	Vice President Market Engagement
Company	Logan Energy Corp.	Logan Energy Corp.
Phone	770.650.6388 x 101	860.210.8050
Fax	770.650.7317	770.650.7317
Email	samlogan@loganenergy.com	kspitznagel@loganenergy.com

6.0 Past Relevant Performance Information

a) Contract: PC25 Fuel Cell Service and Maintenance Contract #X1237022

Merck & Company
Ms. Stephanie Chapman
Merck & Company
Bldg 53 Northside
Linden Ave. Gate
Linden, NJ 07036
(732) 594-1686

Contract: Four-year PC25 PM Services Maintenance Agreement.
In November 2002 Merck & Company issued a four-year contract to LOGAN to provide fuel cell service, maintenance and operational support for one PC25C fuel cell installed at their Rahway, NJ plant. During the contract period the power plant has operated at 94% availability.

b) Contract: Plug Power Service and Maintenance Agreement to support one 5kWe GenSys 5C and one 5kWe GenSys 5P PEM power plant at NAS Patuxant River, MD.

Plug Power
Vinny Cassala
968 Albany Shaker Rd.
Latham, NY 12110
(518) 782-7700 ex 1228

LOGAN performed the start-up of both units after Southern Maryland Electric Cooperative completed most of the installation work and continues to provide service and maintenance during the period of performance.

c) Contract: A Partners LLC Commercial Fuel Cell Project Design, Installation and 5-year service and maintenance agreement.
Contract # A Partners LLC, 12/31/01

Mr. Ron Allison
A Partner LLC
1171 Fulton Mall
Fresno, CA 93721
(559) 233-3262

On April 20, 2004 LOGAN completed the installation of a 600kWe PC25C CHP fuel cell installation in Fresno, CA.

7.0 Host Facility Information

Figure 1, Stennis Visitor's Center

Stennis Space Center is NASA's primary center for Rocket Propulsion Testing and home to the Applied Research and Technology Project Office. It is a multi-agency center with more than 30 resident agencies.

For more than four decades Stennis Space Center has served as NASA's rocket propulsion testing ground. In addition, the Applied Research and Technology Project Office bridge the gap between Earth science research results and the use of data to help its partner agencies make better informed decisions.

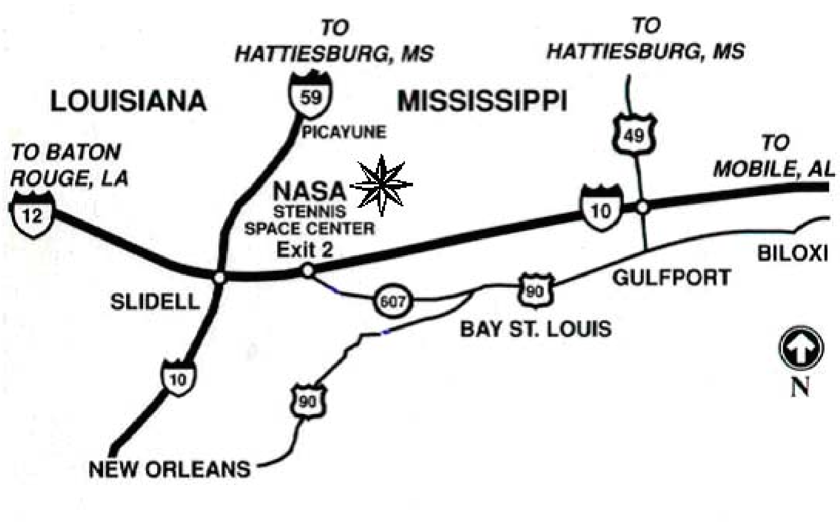
NASA's Stennis Space Center is America's largest rocket test complex and its state-of-the-art facilities include the A, B and E Test Complexes, designed for rocket propulsion testing that ranges from component to engine to stage level. The unique waterway system and 125,000-acre acoustical buffer zone that surrounds Stennis Space Center are considered national assets, and enable testing of large-scale rocket engines and components.

Proof of the contributions made by Stennis Space Center to America's space program was that all the Apollo space vehicle boosters did their job without a single failure, including those for the Apollo 11 mission the landing of the first men on the moon. A new chapter was added in June 1975 when the Space Shuttle Main Engine was tested here for the first time. All the engines used to boost the Space Shuttle into low-Earth orbit are flight certified at SSC on the same stands used to test fire all first and second stages of the Saturn V in the Apollo and Skylab programs.

Space Shuttle Main Engine testing is expected to proceed well into the 21st century.

Over the years, SSC has evolved into a multidisciplinary facility made up of NASA and 30 other resident agencies engaged in space and environmental programs and the national defense, including the U.S. Navy's world-class oceanographic research community.

Stennis Space Center is located in South Mississippi on I-10 at Exit 2 approximately 48 miles west of Biloxi and 45 miles east of New Orleans. Electric utility services are provided by Mississippi Power and LPG is provided by Hancock Propane. Figure 1, above, is an aerial photo of the Stennis Space Center's visitor complex showing the general vicinity of the fuel cell installation.



8.0 <u>Fuel Cell Installation</u>

The fuel cell site was relocated from the visitor's center pictured above in Figure 1 to the Mars Habitat display pictured below in Figure 2 below. The site change occurred after Stennis officials decided that the original location conflicted with the movement of visitors around the static display area. As a result of this decision, the fuel cell product choice had to be changed to an LPGas system from a natural gas unit since the natural piping gas run would have been prohibitively expensive. This site change also necessitated LOGAN to rethink how to incorporate a Combined Heat and Power (CHP) application into the project since there was no thermal load of any kind associated with the Mars habitat display.

Figure 2, Mars Habitat

In the photo captured in Figure 3 below, S/N 250, a Plug Power 5kW LPGas CHP fuel cell power plant is pictured during its installation at the Stennis Mars Habitat display. The trenching seen in the photo accommodated the thermal recovery piping between the fuel cell and the facility. In Figure 4, below, the photo captures the opposite end of the trench

Figure 3, Fuel Cell Site Preparation

Figure 4, Site Preparation

where the thermal piping was connected to a DryCore air conditioner unit chosen to evaluate desiccant technology as a possible energy service compliment to the fuel cell. Figure 5 below depicts a line diagram of the installed site.

9.0 Electrical System

The Plug Power 5kW GenSys5P(LPGas fueled unit), which specifications are included in Appendix section 4, has a maximum output of 4.5 kW at 120 volts ac, 60 Hz. The Mars Habitat site of this installation is a static display that provides visitors a notion of what a future Mars based structure designed to support human life and planetary research would look like. The facility has very minimal loads so under normal operating conditions the unit will provide 2.5 kW service to the building. In addition LOGAN installed an emergency service panel to simulate mission critical circuit support during the demonstration period. The circuits on this panel controlled indoor lighting and outdoor display lighting. During the period of performance there were no grid outages that provided an actual test of the emergency circuit. Figures 15 and 16 in the Appendix section show graphs of cumulative power generation and power generation rate respectively during the period of performance September 2004 though August 2005.

10.0 Thermal Recovery System

Since the Mars Habitat display did not have an independent thermal load to integrate the fuel cell's thermal capacity, LOGAN pursued a new means to utilize the unit"s waste heat. Pictured at left in Figure 6 is a DryKor liquid desiccant air conditioning unit that dries, cools and purifies outside air before introducing it into the Mars Habitat. The unit was designed to operate on an external heat source to regenerate the desiccant through each cooling cycle. In the photo the DryKor cooling module appears on the left and the condensing module appears on the right. The unit can also be seen in Figure 4 above during the construction phase of the project.

Figure 6, DryKor Desiccant Unit

Pictured at right in Figure 7 are the thermal piping connections at the fuel cell that transferred fuel cell waste heat to the DryKore unit. The photo shows the hot water supply and return between the fuel cell heat exchanger and the inlet to the DryKor. While operating at 2.5kW the fuel cell will supply approximately 7,800 btu/h at 130 degrees F. This thermal supply was a good match for the unit's thermal input specifications. Also pictured in Figure 7 are the Btu meter and thermal sensors installed to monitor the fuel cell heat transfer to the DryKor.

Figure 7, Fuel Cell thermal supply piping to the DryKor

Unfortunately the DryKor system failed to meet all expectations as it proved to be much too early in its development cycle support the project's objectives. After spending several months of trouble shooting and system modifications with the manufacturer's assistance, LOGAN was advised by the manufacturer that they could not provide any further support, and the thermal recovery part of the project was dropped.

11.0 Data Acquisition System

In order to monitor the site, LOGAN installed a Connected Energy Corporation (CEC) web-based Supervisory Control And Data Acquisition (SCADA) system that provides high-speed access to real-time monitoring of the power plant. The schematic drawing seen below in Figure 8 describes the architecture of the CEC hardware that supports the project. The system provides a comprehensive data acquisition solution and also incorporates remote control, alarming, notification, and reporting functions. The system picks up and displays a number of fuel cell operating parameters on functional display screens including: kWh, cell stack voltage, water management, as well as external instrumentation inputs including Btus, fuel flow, and thermal loop temperatures. LOGAN's Operations Control Center in Rochester, New York maintains connectivity by means of a Virtual Private Network (VPN) that links the fuel cell to the center.

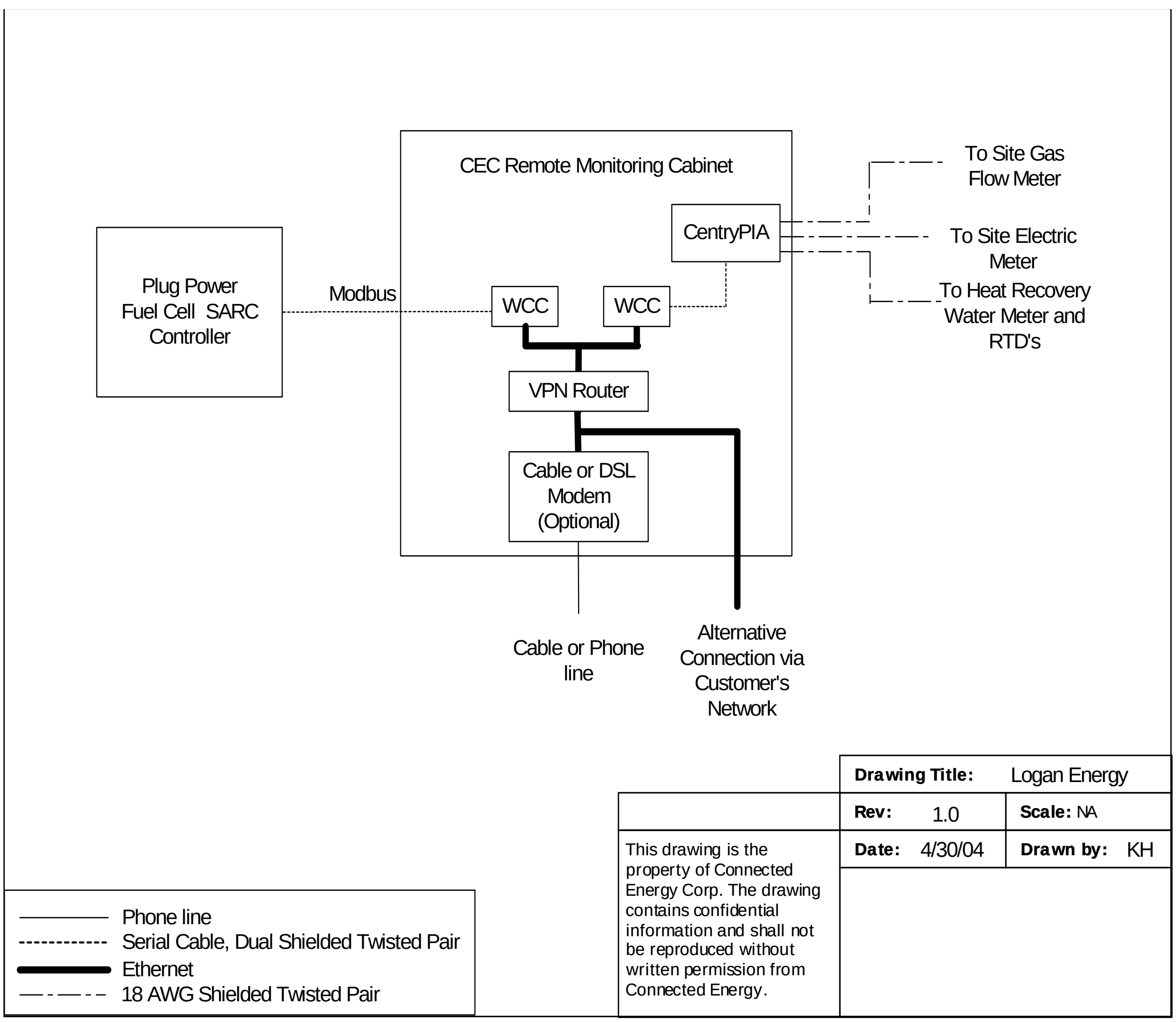


Figure 8, Web based remote monitoring system hardware

12.0 Fuel Supply System

Figure 9, Photo of fuel cell and its 250 gallon LPGas tank

The decision by Stennis personnel to move the fuel cell site to the Mars Habitat, forced LOGAN to change the fuel cell to an LPGas fueled unit from the initial choice of a natural gas unit. This came about once LOGAN determined that the natural gas piping run from the meter serving the visitor's center was too long a distance to cover and at too great a cost to fall within the project budget. Pictured at right is the 250 gallon LPGas bullet installed at the site to provide fuel for the unit. The tank supplies fuel to the fuel cell regulator which provides flows into the system at 14 IWC.

Pictured at right in Figure 10 is a photo of the green LPGas regulator at the inlet to the fuel cell. While operating at a set point of 2.5kW, the fuel cell consumes .53 gallons per hour of vaporized propane. Figures 15 and 16 in the Appendix section show graphs of cumulative fuel flow and power and fuel flow rates with power production rates respectively during the period of September 2004 through August 2005.

Figure 10, Photo of fuel cell with fuel inlet and LPGas regulator.

13.0 Installation Costs

Stennis Space Center					
Project Utility Rates			**Providers**		
1) Water (per 1,000 gallons)		$ -	Stennis		
2) Utility (per KWH)		$ 0.045	Miss. Power		
3) LPGas(per gal)		$ 0.85	Hancock LPGas		
First Cost			**Estimated**	**Actual**	Variance
Plug Power 5 kW SU-1			$ 65,000.00	$ 65,000.00	$ -
Shipping			$ 1,800.00	$ 735.00	$ 1,065.00
Installation electrical			$ 1,250.00		$ 1,250.00
Installation mechanical & thermal			$ 3,200.00		$ 3,200.00
Watt Meter, Instrumentation, Web Package			$ 3,150.00	$ 9,270.00	$ (6,120.00)
Site Prep, labor materials			$ 925.00	$ 2,227.00	$ (1,302.00)
Technical Supervision/Start-up			$ 8,500.00	$ 8,460.00	$ 40.00
Total			**$ 83,825.00**	**$ 85,692.00**	$ (1,867.00)
Assume Five Year Simple Payback			$ 16,765.00	$ 17,138.40	$ (373.40)
Forcast Operating Expenses	Volume	$/Hr	$/ Yr		
LPGas gal/hr @ 2.5kW	$ 0.53	$ 0.45	$ 3,551.74		
Water Gallons per Year	14,016		$ -		
Total Annual Operating Cost				$ 3,551.74	
Economic Summary					
Forcast Annual kWH		19710			
Annual Cost of Operating Power Plant		$ 0.180	kWH		
Credit Annual Thermal Recovery Rate		($0.062)	kWH		
Maintenance			$ 16,000.00	$ 17,932.00	$ (1,932.00)
Reporting			$ 14,000.00	$ 14,000.00	$ -
Project Net Operating Cost		$ 0.119	kWH		
Displaced Utility cost		$ 0.045	kWH		
Energy Savings (Cost)		($0.074)	kWH		
Annual Energy Savings (Cost)		($1,448.94)			

Figure 11

<u>Explanation of Calculations:</u>

Actual First Cost Total is a *sum* of all the listed first cost components.
Assumed Five Year Simple Payback is the Estimated First Cost Total *divided by* 5 years.

Forecast Operating Expenses:

LP Gas usage in a fuel cell system set at 2.5 kW will consume 0.53 gph. The cost per hour is 0.53 gph *x* the cost of LPGas/gallon. The cost per year of $3,551.74 equals the product of cost per hour ($0.44) *x* 8760 hours per year *x* 0.9. The 0.9 is for 90% availability.

LPGas fuel cell systems set at 2.5 kW output will consume 1.6 gallons of water per hour through the DI panel. The total volume of water consumed of 14,016 gallons per year is 1.6 gph *x* 8760 hours per year. The cost per year at $0 equals 14,016 gph *x* cost of water to the site of 0 per 1000 gallons.

The Total Annual Operating Cost, $3,551.74 is the *sum of* the cost per year for LPGas and the cost per year for the water consumption.

Economic Summary:

The Forecast Annual kWh at 19,710 kWh is the product of 2.5 kW set point for the fuel cell system *x* 8760 hours per year *x* 0.9. The 0.9 is for 90% availability.

The Annual Cost of Operating the Power Plant at $0.18 per kWh is the Total Annual Operating Cost at $3,551.74 *divided by* the forecast annual kWh at 19,710 kWh.

Credit Annual Thermal Recovery at -$0.010 equals 7800Btu/h *divided by* 3414Btu/kW. This is then *multiplied by* 0.9 availability *x* 0. 6 estimated thermal load factor *x* the cost of electricity at $0.045 per kWh *x* (-1). As a credit to the cost summary, the value is expressed as a negative number.

The Project Net Operating Cost is the *sum* of the Annual Cost of Operating the Power Plant *plus* the Credit Annual Thermal Recovery.

The Displaced Utility Cost is the cost of electricity paid by Cherry Point MCAS to the local utility.

Energy Savings (Cost) equals the Displaced Utility Cost *minus* the Project Net Operating Cost expressed in kW.

Annual Energy Savings (Cost) equals the Energy Savings *x* the Forecast Annual kWh.

14.0 Milestones/Improvements

This project fell short of the desired goals and achievements due to the widespread destruction at Stennis Space Center and the local region caused by Hurricane Katrina on 29 August 2005.

15.0 Decommissioning/Removal/Site Restoration

In late January 2006, Stennis advised LOGAN that it could gain entry to the base to decommission the fuel cell and restore the site. When the technician arrived he took a number of photos to document the damage to the base and to the fuel cell unit. The photos below provide ample evidence of the destruction caused by the hurricane. Following discussions with the POC, it was decided that the base would take possession of the ruined fuel cell and dispose of it along with the tons of damaged equipment and debris left in the wake of the hurricane.

Post Katrina Site Conditions

The photo at left shows the deconstruction of the Mars habitat site following the passage of Hurricane Katrina.

The photo at left shows the Mars Habitat after clean up of the site. Note remaining foundations of habitat in background behind the fence.

16.0 Additional Research/Analysis

This thermal recovery initiative of this project focused on an attempt to install a fuel cell energy package through integration with an HVAC appliance. To do this LOGAN gained the cooperation of the DryKor manufacturing company to loan a desiccant air conditioning unit to the project. The DryKor unit was installed at the Mar's Habitat to test the efficiency of using waste heat from the fuel cell to satisfy the thermal load required by the desiccant unit. As discussed in Section 8 above, the fuel cell's waste heat output was plumbed to a coil within the desiccant unit to transfer the heat to the incoming airflow across the coil. Outdoor humidly on the Mississippi Gulf Coast region is typically above 85% in the summer months and averages above 70% in the winter months. The desired effect was to dry and purify the incoming air to 50% relative humidity to improve indoor air quality of the habitat. Unfortunately the system proved to be too cumbersome and at too early a stage of product development to operate reliably for an extended period to provide any useful data. After exhausting the manufacturer's interest in supporting the project, and with no other source of assistance, LOGAN was forced to abandon the thermal recovery aspects of the project in April 2005.

17.0 Conclusions and Summary

The untimely occurrence of Hurricane Katrina forced early termination of the Stennis project. At that time the project had achieved 84% operational availability. During the 11 months that the unit operated LOGAN expended a significant amount of time and effort to integrate the DryKor unit with the fuel cell to achieve the project's total CHP objective. In retrospect that time should have been better focused on maintaining the unit to a higher level of availability. Nevertheless the project expectations were correctly directed toward gaining a better understanding of how to integrate a 5kW residential scaled fuel cell with an HVAC appliance in the built environment. Fortunately the lessons learned in planning and developing such a project has not been lost and will be replicated at another location where the investigation can continue.

LOGAN believes it is important to the develop these CHP methods and best practices so that when fuel cells achieve commercial status, the industry will understand cost effective installation techniques to achieve widespread market appeal within and without DOD.

Appendix

1) Monthly Performance Data September 2004 through August 2005

Suggested Format for PEM Fuel Cell Performance Data

System Number:	**SU01B000000250-LPG**		**Commission Date:**	**9/1/2004**		**Site Location(City,State):**	**Stennis, Mississippi**	
Site Name:	**Stennis Space Center**		**Fuel Cell Type:**	**Plug Power PEM**				
Fuel Type:	**LPG**		**Maintenance Contractor:**	**LOGANEnergy Inc.**				
Lower Heating Value:	**943**	**BTU/scf**	**Local Residential Fuel Cost per Therm:**		**$/Therm**	**Local Base Fuel Cost per Therm:**		**$/Therm**
Capacity kW	**5**		**Local Residential Electricity Cost per kWhr:**		**$/kWhr**	**Local Base Electricity Cost per kWhr:**		**$/kWhr**

Month	Run Time (Hours)	Time in Period (Hours)	Availability (%)	Energy Produced (kWe-hrs AC)	Output Setting (kW)	Average Output (kW)	Capacity Factor (%)	Fuel Usage, LHV (kWh)	Fuel Usage, LHV (BTUs)	Fuel Usage (SCF)	Electrical Efficiency (%)	Thermal Heat Recovery (BTUs)	Heat Recovery Rate (BTUs/hour)	Thermal Efficiency (%)	Overall Efficiency (%)	Number of Scheduled Outages	Scheduled Outage Hours
insert month	*insert operating hours*	*insert hours in month*	**1*	*insert produced energy*	*insert output setting*	**2*	**3*	*insert fuel consumption*			**4*	*insert heat recovery*	**5*	**6*	**7*	*insert value*	*insert value*
September, 2004	407	720	57%	1045.2	2.5	2.57	29.03%	4179	1.43E+07	14096	25.03%	0	0	0.00%	25.03%	1	193
October, 2004	684	744	92%	1406.0	2.5	2.06	37.80%	7719	2.63E+07	26037	18.23%	0	0	0.00%	18.23%	0	0
November, 2004	379	720	53%	775.7	2.5	2.05	21.55%	3848	1.31E+07	12980	20.17%	0	0	0.00%	20.17%	0	0
December, 2004	180	744	24%	312.2	2.5	1.73	8.39%	1991	6.79E+06	6716	15.69%	0	0	0.00%	15.69%	0	0
January, 2005	744	744	100%	1520.5	2.5	2.04	40.87%	8256	2.82E+07	27848	18.43%	0	0	0.00%	18.43%	0	0
February, 2005	672	672	100%	1346.0	2.5	2.00	40.06%	7472	2.55E+07	25204	18.02%	0	0	0.00%	18.02%	0	0
March, 2005	712	744	96%	1338.0	2.5	1.88	35.97%	8003	2.73E+07	26995	16.73%	0	0	0.00%	16.73%	0	0
April, 2005	671	720	93%	1170.0	2.5	1.74	32.50%	7624	2.60E+07	25717	15.36%	0	0	0.00%	15.36%	0	0
May, 2005	570	744	77%	1412.3	2.5	2.48	37.97%	6126	2.09E+07	20664	23.07%	0	0	0.00%	23.07%	0	0
June, 2005	720	720	100%	1754.9	2.5	2.44	48.75%	8375	2.86E+07	28250	20.97%	0	0	0.00%	20.97%	0	0
July, 2005	744	744	100%	1855.3	2.5	2.49	49.87%	8472	2.89E+07	28577	21.91%	0	0	0.00%	21.91%	0	0
August, 2005	636	744	85%	1744.0	2.5	2.74	46.88%	6549	2.23E+07	22090	26.65%	0	0	0.00%	26.65%	0	0
			#DIV/0!			#DIV/0!	#DIV/0!		0.00E+00	0	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!		
			#DIV/0!			#DIV/0!	#DIV/0!		0.00E+00	0	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!		
			#DIV/0!			#DIV/0!	#DIV/0!		0.00E+00	0	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!		
Running Totals																	
	Total Run Time	**Total Hours in Period**	**Total Availibility (*8)**	**Total Energy Produced**	**Average Output Setting**	**Total Average Output (*9)**	**Total Capacity Factor (*10)**	**Total Fuel Usage**	**Total Fuel Usage**	**Total Fuel Usage**	**Average Electrical Efficiency (*11)**	**Total Thermal Heat Recovery**	**Average Heat Recovery Rate (*12)**	**Average Thermal Efficiency (*13)**	**Average Overall Efficiency (*14)**	**Total Outages**	**Total Hours**
	7119	8760	81%	15680.1	2.5	2.20	35.80%	78614	2.68E+08	265173	19.96%	0	0	0.00%	19.96%	1	193

Figure 12

2) Documentation of Acceptance Test.

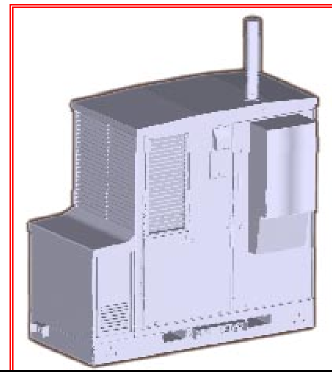
Installation Check List			
TASK	**Initials**	**DATE**	**TIME (hrs)**
Batteries Installed	KW	8/30/04	2
Stack Installed	KW	8/30/04	3
Stack Coolant Installed	KW	8/30/04	1
Air Purged from Stack Coolant	KW	8/30/04	0.5
Radiator Coolant Installed	KW	8/30/04	2
Air Purged from Radiator Coolant	KW	8/30/04	1
J3 Cable Installed	KW	8/30/04	1
J3 Cable Wiring Tested	KW	8/30/04	0.5
Inverter Power Cable Installed	KW	8/30/04	0.5
Inverter Power Polarity Correct	KW	8/30/04	0.5
RS 232 /Modem Cable Installed	KW	8/30/04	0.5
Natural Gas Pipe Installed	KW	8/24/04	8
DI Water / Heat Trace Installed	KW	8/30/04	3
Drain Tubing Installed	KW	8/30/04	1
Commissioning Check List and Acceptance Test			
TASK	**Initials**	**DATE**	**TIME (hrs)**
Controls Powered Up and Communication OK	KW	8/31/04	4
SARC Name Correct	KW	8/31/04	1
Start-Up Initiated	KW	8/31/04	5
Coolant Leak Checked	KW	8/31/04	1
Flammable Gas Leak Checked	KW	8/31/04	1
Data Logging to Central Computer	KW	8/31/04	1
System Run for 8 Hours with No Failures	KW	9/1/04	8

Figure 13

3) Plug Power GenSys5P Product specifications

Plug Power Fuel Cell System

The GenSys5P is a 5kWAC on-site fuel cell power generation system. Designed to be connected to the existing power grid, the 5P is a clean and efficient source of power that uses LP Gas as its fuel.



Specifications

Physical	Size (L X W X H):	84 1/2" X 32" X 681/4"
Performance	Power rating:	5kW continuous
	Power set points:	2.5kW, 4kW, 5kW
	Voltage:	120/240 VAC @ 60Hz
	Power Quality:	IEEE 519
	Emissions:	$NO_X < 5ppm$
		$SO_X < 1ppm$
		Noise < 70 dBa @ 1meter
Operating Conditions	Temperature:	0°F to 104°F
	Elevation:	0 to 750 feet
	Installation:	Outdoor/CHP
	Electrical Connection:	GC/GI
	Fuel:	Natural Gas
Certifications	Power Generation:	CSA International
	Power Conditioning:	UL
	Electromagnetic Compliance:	FCC Class B

Dimensions	
Length	84 inches
Width	32 inches
Height	68 ¼ inches
Operating Requirements	
Fuel Type	LP Gas
Temperature	0 degrees F to 104 degrees F
Outputs	
Power Output	5kW
Voltage	120/240 VAC @ 60Hz
Noise	< 70 dBA@ 1 meter
Certifications	
CSA International	Fuel Cell System
UL1741	Power Conditioning Module
IEEE P14741	Grid Parallel Generation

Figure 14

4) Performance Graphs

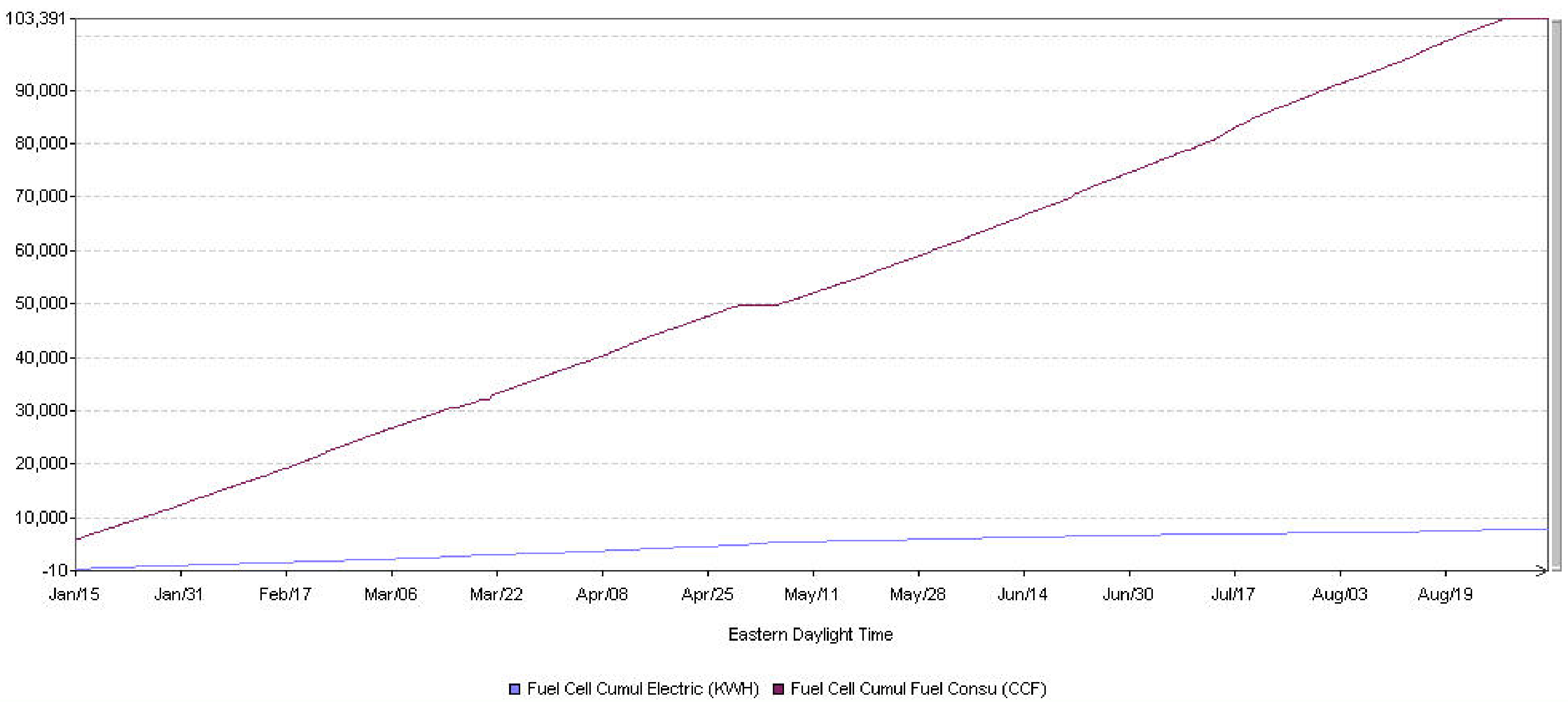


Figure 15, Graph of fuel cell cumulative electric and cumulative fuel through August 2005

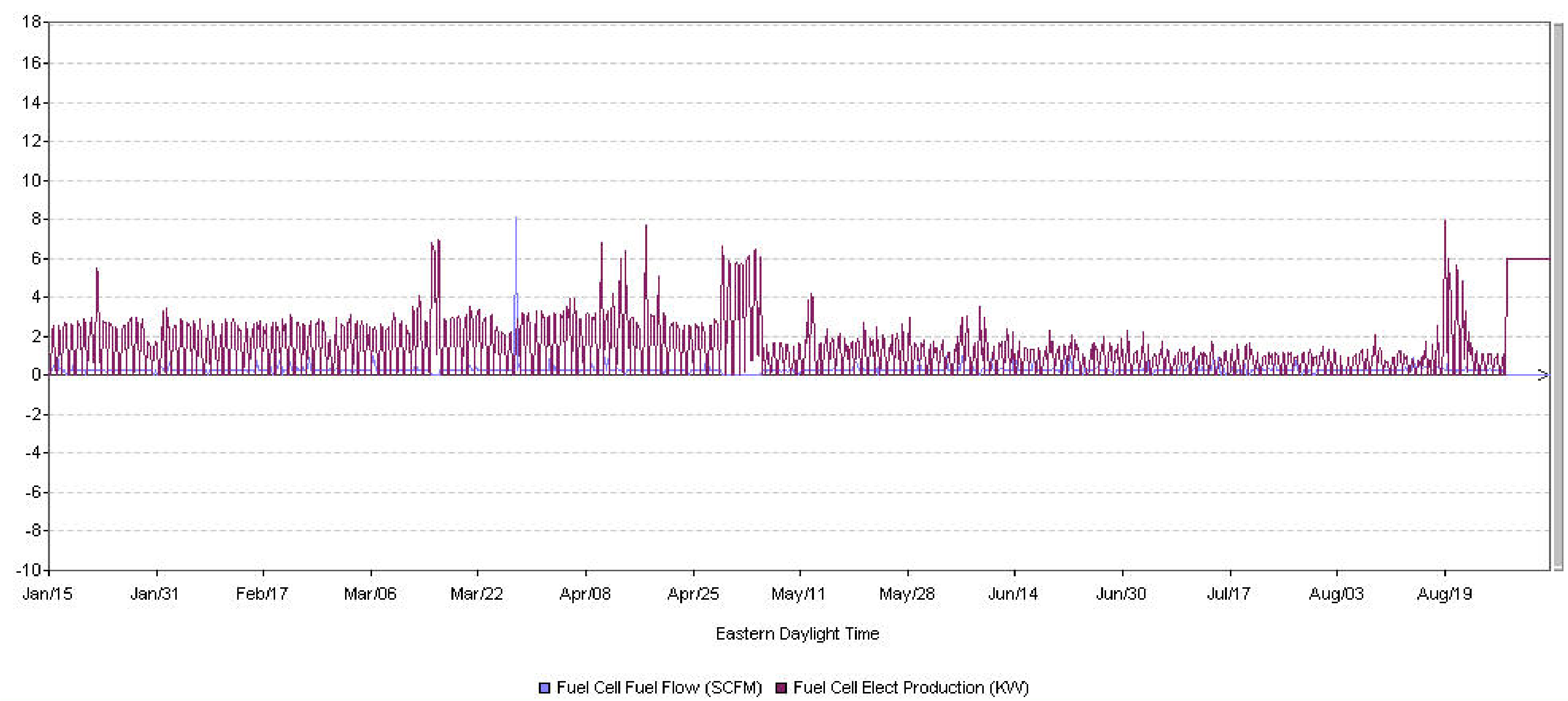


Figure 16, Graph of fuel cell fuel power generation over fuel flow January through August 2005